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THE ETIOLOGY OF MALARIAL FEVER WITH SPECIAL REFERENCE TO THE GROUND, WATER LEVEL, AND THE PARASITE

Leonard ROGERS

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regiment and go on other duty. I hope some one will take it up. If, for instance, spring tertians haunt one corner of the lines, quartans another, and so on, the only conclusion possible to come to will be that the sources of the poisons are extremely local; a number of reasons which it is impossible to go into here suggest the same view; and if the point is proved it will probably lead to practical sanitary results of the greatest value. The golden rule for us in India is not so much to study the details of structure of the parasite as to find out how far it is prevalent in the country and *how it lives in external nature.*

I have forgotten to remind the reader that it is only in fresh infections of summer-autumns that crescents set in after the subsidence of the fever. As they may continue in the blood for one or even two months after the first attacks, and as the patient may have several recurrences during that time, or even attacks of other species of parasites, it very frequently happens that in old cases we get crescents together with small amœboid bodies and with spring fever forms; but the observer must never make the mistake of supposing that the crescents have to do with the febrile symptoms (unless they cause a kind of cachectic fever). Surgeon-Captain McNaught's article seems to afford a good illustration of some of these remarks. He is to be congratulated on his flagellate bodies, but these and his discs are only evolution forms of crescents; that is all the parasites which he describes appear to belong to the mosquito cycle; so that he is quite justified in stating that there was no relation between them and the type of the fever. He will find a closer relationship when he considers more deeply the amœboid bodies which he has already seen. It is not advisable to attempt to compare the type of fever with the observed form of the parasite, until one has mastered the classification of the latter together with Marchiafava's observations on the corresponding febrile conditions. Surgeon-Captain Maynard states that he finds no flagellate bodies, but describes exactly some phenomena due to flagella (pages 417 and 418). Unfortunately he has missed all the summer-autumn fever forms. The phenomenon of *swarming* of pigment is due in mosquito-cycle parasites to the approaching release of the flagella, and in fever-cycle parasites to the approaching death of the animal. For this reason a specimen containing the latter should not be examined much over 20 or 30 minutes; it is better to make a new one. Swarming occurs rapidly in all forms which have been crushed (as in Field A). The bubbles connected with crescent-spheres are due to the remains of the corpuscle (Mannaberg), and are not of the same nature as the bioplasm-bubbles of blood-plates.

(*To be continued.*)

THE ETIOLOGY OF MALARIAL FEVER WITH SPECIAL REFERENCE TO THE GROUND, WATER LEVEL, AND THE PARASITE.*

BY LEONARD ROGERS, M.B., B.S., (LOND), F.R.C.S. (ENG.), SURGN.-LIEUT., I.M.S.

(*Read at the Feby. Meeting of the Calcutta Medical Society.*)

THE research on which the following paper is based was undertaken in order to try to determine what proportion of the cases of fever, occurring among the men of the 11th Bengal Infantry, at Doranda, Chota Nagpur, were of a malarial origin, and whether there are any clinical differences between the cases in which the malarial organism is found and those in which it was not found. The proportion of cases of fever in which the plasmodium malariæ of Laveran has been found by different observers in India varies very widely, from 0 per cent. by some who have not been able to satisfy themselves of the existence of the organism at all, through 11·7 per cent. by Vandyke Carter in 1887, 28·71 per cent. by Maynard in 1895, up to from 77 to 92 per cent. in different series of observations by Hehir.

I have not, however, been able to find any record of an examination of a large number of consecutive cases of fever of which minute notes were at the same time taken of each case, and of a clinical comparison made between the cases in which the parasite was found and those in which it was not found, although such a method might be expected to yield valuable results, one of which would be to test the correctness of Dr. Crombie's view, that three-fourths of the cases classed under the head of "Ague" in the returns of the Army, Civil Hospitals and Jails are not genuine intermittent malarial fevers.

In addition to examining the blood and taking tabulated notes of the cases, in which a slight knowledge of short-hand has proved of extreme value, observations of temperatures, including the ground temperature at a depth of 6 feet and what has proved of the greatest interest, measurements, taken by means of a metallic tape and a float twice a week, of the level of the water in three wells situated immediately around the lines, have been made in order to determine the etiological influence, if any, of these meterological changes.

In order to ensure accurate results, the following precautions were taken. Every man who came to hospital complaining of fever was detained, and his temperature taken as a rule every four hours, charts being kept. No case was excepted as one of fever unless a rise of temperature was recorded whilst in hospital. The exact date and hour of the first onset of the fever, as determined by the shivering which almost invariably occurred, was noted. A careful

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enquiry was made as to any cause, such as chill, fatigue, getting wet, exposure in the sun, etc., and the result noted. The state of the tongue, bowels, headache, the size of the spleen, age of the patient, previous attacks of fever recently, were noted on admission, and subsequently the duration of fever in days, both the total and that after the giving of quinine were recorded. The blood was examined in each case on the first morning visit to hospital after a rise of temperature had been recorded, and quinine, which was withheld up to this time, was now given in 10-grain doses, three times a day, as long as fever lasted, and then in one morning dose of 10 grains together with a tonic for a few days after, all the cases being treated alike. The blood specimens were all taken in the morning usually between 8 and 10 A.M., and only one specimen was examined from each case, and always for half an hour, with a $\frac{1}{12}$ oil immersion lens and Nos. 2 and 4 eye-piece.

The method of making the blood specimens, which were adopted after a month's trial of many different ways, is as simple, as it is effective in obtaining with certainty a well-fixed specimen of the blood. It was very soon obvious, from the fact that as many as 8 fresh cases have occurred in one day, that in order to examine a consecutive series, permanent specimens must be used. In fact, I very soon gave up examining fresh specimens, owing to the bewildering nature of the multitudinous *post-mortem* forms which soon appear under an oil immersion lens in such specimens, and I have come to the same conclusions as Maynard, in preferring unstained specimens fixed in the vapour of 2 to 4 per cent. osmic acid. I may, however, mention that I have recently discovered that blood may be very well fixed with $\frac{1}{2}$ per cent. sodium citrate.

The best method of getting evenly and thinly-spread out specimens is to quickly smear a very small drop of blood over one coverslip by means of the edge of another, and to then invert the specimen over the osmic acid. The specimens were then mounted dry, being fixed down to the slide by four small drops of hard paraffin. The red corpuscles are very clearly defined in this way, much more so than if the specimen is mounted in any medium with which I am acquainted; and they may be stained if desired. Specimens thus mounted keep very well.

I shall only briefly refer to the morphology of the parasites found, as this part of the subject has been fully reported on by other observers recently, and the precise forms found is not of much importance in relation to the main question at issue in this paper. I happen to have examined the blood of exactly 100 cases of fever, the last 76 of which were consecutive cases. Of the 100 cases 64 were simple regular quotidian cases, 18 were irregular quotidians, by which term I mean cases in which there was a rise of temperature each day, but in which there was some irregularity, such as the intermission not having quite reached the normal on one day. In none of these cases was the temperature above normal for more than two days continuously, 10 were tertian, and one was a 21-day continued fever of the so-called Calcutta or Bombay type, in which no parasites were found on repeated examination; whilst in 7 the temperature only rose on one day, so that the type could not be determined. There were no cases of remittent fever, and the whole series were of a very mild type. The organisms were found in 32 per cent. of the whole, or in 29·6 per cent. of the simple quotidian, in 44·44 per cent. of the irregular quotidian which were of a more severe type than the simple form. in 40 per cent. of the tertians, and in 14·28 per cent. of the one-day cases, which were the mildest of the whole series.

With regard to the proportions of the stages of the organisms which were found, classifying them according to Dr. Patrick Manson's Chart which appeared in the *British Medical Journal* in December 1894, I find that 41 per cent. were unpigmented, belonging to the A, B, C and D rows, the ring-shaped forms, often with small processes, of row E being by far the most frequently seen. In the small, finely pigmented form of row E there were 33·71 per cent. the medium-sized pigmented forms of rows F, G and H formed 15·66 per cent., the large much-pigmented forms of rows H, I and J, 7·23 per cent. and the sporing forms K 9 and K 10 formed 2·49 per cent., three-fourth of the last two classes being found in the tertian cases, in which the organism found were on the average distinctly larger than those seen in the quotidian cases, sufficiently so I, think, to have enabled me with my present experience to have diagnosed the type in some of the cases by their appearance.

In one case an officer of the 11th Bengal Infantry was attacked by fever in Doranda thirteen days after exposure in the terai. On examining his blood after he had fever for four or five days, and had taken quinine, two well-marked centrally pigmented crescents were found, but no developing organisms. He had no fever the next day, but had a relapse twenty-three days later, when numerous small pigmented parasites were found in his blood, but no crescents. This is the only case in which I have found crescent-shaped organism. It occurred to me that the terai fevers may owe their virulence and frequent relapses to the presence of these semi-lunar bodies, hence resembling in this respect the summer-autumn fevers of Marchiafava and Bignani; but, on the other hand, the fact of my not finding them in any other cases may be due to the fact that nearly all my cases were examined on the first day or two of the attacks, and these semi-lunar bodies are very seldom seen until fever has lasted for some days. On referring to Dr. Maynard's recent paper (*Indian Medical Gazette*, November 1895), I see he has found these

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forms in 6 cases out of 70 examined, but in all except one of them fever had been present for ten or more days, or longer than in any of my cases. The relation of the presence of these bodies to the severity of the cases deserves careful study in order to determine if the facts found out by Italian observers with regard to them apply to the malarial fevers of India, as, I think, will very likely prove to be the case; if so, their presence will be of great prognostic value.

I will now pass on to the analysis of the 76 consecutive cases in which the blood was examined, and in 23 or 30·26 per cent. of which the organism was found. I purposely say found, and not present, as the organism may obviously be present in the blood of a patient, but yet may not be found in the few thousand corpuscles of the small drop of blood taken on one occasion only, and that not necessarily the most favourable one. [Although, as a rule, the time was but a very few hours before the rise of temperature occurred, and hence was not, on the other hand, a particularly unfavourable one.]

If some of these cases were truly malarial, by which term I mean caused by the plasmodium malaria, whilst otherwise of a different nature altogether as the class of fevers variously called simple continued ephemeral, thermic, etc., and due to chills, fatigue, exposure to the sun and the like, then a minute analysis of the history of the cases, the symptoms, [shivering, the size of the spleen, and the state of the tongue and bowels are likely to be of the most important,] the temperature charts, and the effect of treatment, especially the duration of the fever after the exhibition of effective doses of quinine, all being controlled by an examination of the blood; would naturally be expected to yield some points of differentiation between the two groups. Let us see how far this is the case.

Firstly, with regard to the occurence of shivering. This symptom occurred in 93·42 per cent. of the cases, so that allowing for it occurring during sleep, and being so slight as not to be noticed it is practically always present. In the great majority of the cases it was noted if it was severe or slight. (For the sake of preventing repetition, I shall denote the cases in which the organism was found as "parasite cases," and those in which it was not found as "non-parasite cases." The shivering was slight in 26 per cent. and severe in 39 per cent. of the parasite cases, but slight in 49 per cent. and severe in only 30 per cent. of the non-parasite cases, shewing that in this respect the former were on the average more severe than the latter.

The hour of the onset of the rigor was as follows :—From midnight to 6 A.M., 0 per cent., from 6 A.M. to noon, 16·48 per cent., from noon to 6 P.M., 57·14 per cent., and from 6 P.M. to midnight. 26·38 per cent., the proportions being very similar in both the parasite and non-parasite cases. Between noon and 10 P.M. 77 per cent. of the cases began. (This fact I think supports the general belief that infection takes place most frequently at night, which would allow sufficient time for the organisms to reach maturity and divide by the time the rigors usually take place.

The state of the bowels and tongue is of special interest in relation to the opinions of a writer to believe that most Indian fevers are due to the absorption of ptomaines from the intestinal canal. The tongue was quite clean in 58 per cent. of the cases, and only in 5·4 per cent. was it much furred. It was clean in a slightly larger number of the non-parasite cases (60 per cent.) than in the parasite cases (54·5 per cent.), but this difference is again very slight. Diarrhœa was not noted in a single case, and constipation in 13 per cent. only. Headache was present in over 90 per cent. of the cases, being more constantly present in the parasite cases (95·45 per cent.) than in the non-parasite cases (87·76 per cent.).

I had not time to examine for tender spots in the abdomen in my cases, but know from experience that the average sepoy will very often complain of discomfort when his abdemen is being palpated, whatever disease he may be suffering from. The rarity of thickly-coated tongues and of bowel symptoms is, however, sufficiently marked to convince me that Surgeon-Major Ronald Ross' view, that most cases (90 per cent.) of Indian fevers are due to absorption of ptomaines from the intestinal canal, are not applicable to the series of cases under consideration, apart from the fact that poisonous products of digestion are constantly being absorbed from the digestive track, and being eliminated from the liver during health, as proved by the poisonous nature of blood from the portal vein, if it is allowed to reach the general circulation before passing through the liver. As, however, Dr. Ross has been converted to the parasitic origin of malarial fevers, since writing the papers referred to in the *Indian Medical Gazette* of 1892, he may also have modified his views on this point, on which, as far as I know, he has not recently published anything. So I need not discuss this question any further here.

The size of the spleen on admission was carefully noted. It was enlarged in 43·48 per cent. of the parasite cases, in 21·74 of which it could be felt below the ribs, whilst in the non-parasite cases it was enlarged in only 32·08 per cent. of which it could be felt below the ribs in 18·86 per cent. Here, again, the difference, although not very great, points to parasite cases being on the average somewhat more severe than the non-parasite ones.

Passing on to an examination of the temperature charts, the intermittent nature of the fever is well seen, as in the few cases (9 in number), in which the temperature only fell about 100°F. instead of reaching the normal at the end of a

paroxysm, the intermission was still well-marked, and in a few (2 or 3) of these, organisms in different stages of development were found in the blood, accounting for the irregularity. The duration of the paroxysms of the fever was deduced from the four-hour temperature charts.

In the parasite cases it was found to average 13·52 hours, and in the non-parasite case 13 hours.

The average stay in hospital was, in the parasite cases, 16·91 days, and in the non-parasite cases, 13·05 days.

In the parasite cases, the temperature rose to over 101° before the use of quinine in 87 per cent., and of the non-parasite cases in 77 per cent.

Thus in every single respect the fever of the parasite cases was distinctly, but only slightly, more severe in the average than that of the non-parasite cases, and what is of the greatest importance, this relationship held good of the duration of the fever after the exhibition of quinine in quantities of 21 grains during the 24 hours.

The height to which the temperature rose during the paroxysm immediately following the examination of the blood is of importance, in relation to the finding of the parasite, as one would expect them to be present in larger numbers, and hence to be more easily found, shortly before a considerable rise of temperature than before a slighter elevation. This was also found to be the case, as in the parasite cases the temperature rose to between 101° and 104°F., and 87 per cent. of the cases during the paroxysm preceding the examination of the blood, and in 86 per cent. of them during the paroxysm following the examination of the blood, whilst in the non-parasite cases, it rose to the same height in 77 per cent. of the cases during the preceding, and only in 57 per cent. during the succeeding, paroxysm. From the foregoing analysis it will be seen that in the case of every single point noted, the cases in which the parasites were found were on the average distinctly but slightly more severe than the cases in which they were not found, but the difference was not sufficient to differentiate the former clinically from the latter. On the contrary, both series shew precisely the same symptoms, only in a somewhat different degree of severity. The obvious conclusion is, that all the cases are of essentially the same nature and caused in the same way. I have come to the conclusion, that every case (except the one of continued type which is not included in the foregoing analysis) was of malarial origin, and due to the malarial organism, but that in this very mild series of cases the parasite was not present in sufficient numbers to be found in all the cases by means of a single examination of the blood for the short period of half an hour, during which time I have calculated that only some three or four thousand red corpuscles can be carefully scrutinised with an oil immersion lens. This view is supported by the fact that, as a rule, only three or four organisms were found in the successful examination, although many more were. The fact that I have been forced to come to this conclusion, although I had expected and hoped to have been able to chemically differentiate the parasite and non-parasite case into two distinct classes, adds to, rather than detracts from, the value of the opinion arrived at; and it is further supported by the results to be mentioned in the latter part of this paper.

The results of the enquiry into the history of predisposing causes must be mentioned here. In only 20·64 per cent. of the cases noted was any such history obtained, namely, of fatigue in 27·22 per cent. of chill in 5·15 per cent. of getting wet in 5·15 per cent. and of exposure in the sun in 3·09 per cent. In how many of these cases the fatigue, chill, etc., was a symptom of the onset of fever, rather than a preceding event, it is impossible to say, but it is evident that in this series they played a very small part in actually causing an attack. What does appear to have had a very definite effect, I will now go on to demonstrate in detail. I refer to the alterations in the level of the ground water beneath the lines in which the men live in mud huts. But before coming to this, I will just mention briefly the result of an elaborate and laborious analysis of the medical history sheets of the four companies of the 11th Bengal Infantry, stationed at Doranda, which was undertaken to try to determine if previous attacks of ague tended to predispose to, or protect from, further attacks. I had noticed that "B" Company, which had been stationed at Burma only three years ago, suffered less than the other companies, and it seemed possible that the severe type of fever met with there might have protected them from the mild fever of Doranda. The number of men of "B" Company who had had fever at Burma proved to be very small, however, and they suffered this year (1895) in Doranda in the same proportion as the general average of the whole wing. One interesting point came out as a result of this enquiry. Of the whole four companies, just over 25 per cent. (25·44) suffered from fever this year (1895), but the proportion suffered in relation to previous attacks at different periods of remoteness, varied considerably, and yet with considerable uniformity in the different companies. Thus, of those who had had fever during 1893 or 1894 at Bareilly, 24·44 per cent. suffered again in 1895, or just about the general average. But of those who had not had fever in 1893 and 1894, but had suffered from it between 1890 and 1892 inclusive, 38 per cent. in 1895, or more than half as much again as the general average. On the other hand, of those who had not had fever for five years or more, only 20·29, or less than the general average, suffered this year (1895 , and of

those who had over five years' service, but had never been in hospital for fever, only 11·94 suffered in 1895. This seems to show that a certain proportion of the men—in this instance 15 per cent of the whole—are relatively immune to malarial fevers, whilst those who have suffered fairly, recently, but not within the last two years, are most susceptible I am unable to explain this point, which will require statistics of a more extensive nature in order to confirm or refute, but mention it in the hope that some here will be able to throw light on it. It is worth noting that the variations in the number attacked in different companies depended chiefly in the proportion of the most susceptible class which was attacked. Thus, in "B" Company which suffered least, only 27·27 per cent. of this class suffered, whilst of "D" Company, which suffered most, 42·1 per cent. were attacked.

I now come to the meteorological side of my enquiries. The ground temperature during the months of from July to October, during which the fever was most prevalent, only varied from 81°Fah. to 77°Fah., which will be intermediate between that which would prevail in the plains of India and in such countries as Italy, and cannot be shewn to have influenced the fever curve. The same remark applies to the maximum and minimum air temperatures. The amount of moisture in the air, as judged by the difference between the wet and dry bulb thermometer as recorded in Ranchi (2 miles from Doranda), was very constant throughout the height of the rains, and does not show any relationship to the fever curve during this period; but since the rains have ceased, I have noticed a tendency for one or two cases of fever to occur especially during cloudy weather, even when no rain fell. On plotting out a curve of the moisture in the air, and comparing it with the fever curve during the later period from September 1st to November 1st, it appeared that there were on seven occasions an increase of the air moisture curve, and on five of these was a corresponding rise of fever curve; whilst at the time of the occurrence of one rise, there were no fever cases.

Thus there is a distinct tendency to the occurrence of isolated cases of fever in relation to an increase of the moisture of the air. This is very easily explained on the parasitic theory of these cases, as any organisms which gain access to the air may be expected to survive long, and so have a greater chance of causing the disease, in a moist atmosphere, than in a dry one, which would probably soon kill them. The relationship of a constantly high ground water-level to a great prevalence of malarial fevers, and of the effect of lowering this level even by only a few feet, as in Algeria, in reducing this prevalence, is too well-known to need any emphasising here. The effect of a prolonged rainy season, in increasing the fever rate, was very well illustrated by the statistics of 1894.

The exact relationship of the curve of the rainfall to that of the fever, however, differs very much in different parts of the country, as the rise of the fever curve may either precede, coincide with, or follow that of the rainfall. Again, the development of malaria may, according to the 8th edition of Park's Hygiene, be connected either with the rise or fall of the ground water. The influence of a fall in increasing malaria is chiefly seen in places where a marshy country is completly submerged during the rains, or in places were the ground water-level is very near the surface of the ground at this time. Apart from these causes, as remarked in Davidson's "Diseases of Warm Climates" "the seasonal prevalence of fevers is not determined, as many suppose, by the drying up of the rains."

In Doranda the fever curve coincides closely with the rain curve. I show you here a chart in which the rise and fall of the ground water-level in the 11th Bengal Infantry lines, as determined by the average of the level of the water in three wells immediately around the lines, taken twice a week, is shewn above; whilst the curve shewing the average weekly occurrence of fresh cases of fever is depicted below. The correspondence of the four rises and falls of the two curves is very striking.

During June there was practically no fever, only 5 cases in the whole month. On June 3rd the water-level reached its lowest point, namely, 34 feet from the surface. Between that time and the end of June, it rose to 28 feet, 9·98 inches of rain having fallen during the month in Doranda. During the first week of July the water rose to 22 feet 4 inches, and fever began to be more prevalent, averaging 0·57 fresh cases daily. From the 8th to the 14th the water rose rapidly to 16½ feet, and the fever increased to an average daily rate of 2·16. Then the rains lessened, and the water-level not only ceased to rise, but actually fell 7 inches during the next five days. Coincidently with this fall, the fever prevalence decreased to one fresh case daily. The water then rose rapidly during the time, from the 18th July to the 1st of August, to a distance of 8 feet 8 inches from the surface, and the fever rate increased at the same time to 2·5 fresh cases a day. There was then a second lessening of the rain s, and a second fall of the water-level by 7 inches, again accompanied by a marked decrease of fever from a daily average of 2·5 to one of 0·86. A third rise in the water-level carried it to its maximum for the year, only 5 feet 3 inches from the surface, on August 18th, or a difference of nearly 30 feet from its minimum level. Coincidently with this rise, the fever rate also rose to its maximum for the year, an average of three fresh cases a day. A arge decrease in the rains, accompanied by a steady fall in the level of the ground water, continued up to September 15th, and with it a long, steady fall in the fever rate to a daily average rate of 0·71. Then 5 inches of rain fell in a little over 24 hours,

and the water-level rose for the fourth time by 1½ feet, and at the same time the fever rate rose to a daily average of 1·43. After this there was a more rapid fall of the water-level, interrupted only by a slight rise on October 27th, which apparently was too slight to affect the fever rate; the water-level having by this time reached a depth of 13 feet. The fever curve during this period presents a slow and steady fall, and reached the normal on November 10th, when the water-level was at a depth of 18½ feet. These curves appear to me so remarkably parallel as to carry conviction that there must be some etiological relationship between the rise and fall of the water-level and the increase and decrease of the fever curve, and this relationship is strongly supported by another observation which I have made. When engaged daily in examining the accumulating blood specimens from the consecutive cases of fever, I was much struck by the fact that at one time I found the parasite in nearly half the cases examined, while a little later, in as many as ten specimens running, on which the same time and care was bestowed, negative results were obtained. On subsequently comparing these periods with the water-level chart it became apparent that the parasite was most frequently seen in cases which occurred during a rise in the water-level, and less frequently when it was falling. This observation was found to hold good with regard to each of the four rises and falls of the ground water. During the first rise the organism was found in 5 out of 11 cases examined—that is, in 45·45 per cent.; but during the succeeding fall it was not once found in 4 cases. During the second rise it was found in one out of 5 cases examined, or 20 per cent., but not in either of the two examined during the following short fall. I do not lay any stress on these figures, as every case which occurred was not examined, except so far as to corroborate those obtained during the two last rises and falls, during which every case was examined, and of which the figures are as follows:—During the rise to the maximum water-level on August 18th, the organism was found in 57·89 per cent. of the 19 cases which occurred, but during the succeeding long fall, lasting from August 18th to September 15th, it was only found in 20 per cent. of the 35 cases examined. During the fourth rise terminating on September 22nd, it was found in 33·33 per cent. of the cases, and during the following final fall, among the cases which occurred (between September 22nd) up to October 19th, the organism was only detected in 17·18 per cent. Again, of all the consecutively examined cases which occurred during the periods of rising ground water-level, the parasite was found in just 50 per cent., whilst during the periods of a falling ground water it was detected in only 19·56 per cent., or two and a half times less frequently than in the former case.

This observation and the parallel nature of the curves of the water-level and fever appear to me to be complimentary to each other, as the same explanation applies with equal force to both. Every one, even the detractors of the much-put-upon mosquito, will acknowledge that the malarial organism lives in the ground of infected countries. In addition to the undoubted effect of drinking water in causing malarial fever, it is also universally admitted that perhaps an even commoner mode of entrance of the organism is through being inhaled into the lungs and so reaching the blood of the pulmonary capillaries. When the water rises some feet in the ground, it must displace a correspondingly large number of cubic feet of air which will pretty certainly carry up with it a certain number of malarial organisms, which will therefore be present in the air in a larger number during a period of rising ground water than when it is stationary or falling. If this is so, the effect should be greater the nearer the water is to the surface if the rise of the water-level be fairly equal. This is precisely what is seen in my chart, as the second rise of the fever curve has a greater amplitude than the first, and the third than the second, the water-level having risen towards the surface at a fairly uniform rate during this period. The fourth rise of the water-level is of less amplitude than the first three, and the rise in the fever curve is correspondingly slight. [I may just mention here that a curve of the prevalence of dysentery in Doronda during this rainy season showed three elevations corresponding with the second, third and fourth rises in the ground water, but in this case the amplitude of the dysentery variations were in proportion to the distance of the rise of the water-level, and not in proportion to its nearness to the surface.] [The theory here propounded, that the increase of the fever in Doronda in 1895 was due to the displacement of the air by the rises of the ground water-level, is all the more likely to be correct, because the facts on which it is based were first obtained, and the explanation subsequently thought out]. There is one more point which tends to confirm both this explanation and also the views expressed in the earlier part of this paper, that all the cases were of malarial origin. I have worked out the curves which represent the prevalence of the cases in which the organism was found, and also that of those cases in which it was not found in relation to the ground water curve. The curves of the two classes very closely correspond both with each other, and with the ground water curve, but the curve of the parasite cases rises and falls some days before the curve of the non-parasite cases. This fact appears to me to be of great interest and importance, for in the first place it confirms the view that the two classes of cases are of essentially the same nature and caused in the same way; and secondly, it strongly sup-

ports the view that the only difference between the two classes is that the cases in which the parasites are not found are of a milder nature, due to there being fewer organisms present in their blood in them. In conclusion, I must say that I fully recognise that the fevers of India necessarily differ greatly in their occurrence and etiology in different parts of the country, and I think that my observations with regard to the relation of their prevalence to the variations in the ground water-level will only apply to places in which these variations have a great amplitude as they have in Doronda. At any rate, the careful study of this question in different places ought to throw much light on the great question of the etiology of malarial fevers, and so lead to scientifically based preventive measures.

Drs. Simpson, K. C. Bose, K. N. Dass and Moir took part in the discussion which followed the reading of the paper, and Dr. Rogers replied.

CREASOTE AS AN ANTIPYRETIC.

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42nd Gurkha Rifles, Shillong.

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That creasote, when applied externally, acts as an antipyretic, does not appear to be generally known: not one of the text-books I have consulted, has a word to say on the subject.

Some months ago I first heard of this action of creasote, and during the last seven weeks I have had the opportunity of trying its effect on five cases, of which short summaries are given below.

The ordinary way of applying the creasote is to rub about 10 minims of it well into the skin of the abdomen and cover over with spongiopiline and a bandage, which should be removed after about an hour.

Case I.—Rifleman Bakhan Sing Gurung, 42nd Gurkha Rifles, age 24, was admitted into hospital on 21st October, with lobar pneumonia of the right lung. On the first two days the evening temperature was 103°, but at 4-30 P.M. on the third day it had risen to 104° (pulse 108, respiration 36). Creasote was applied to the abdomen at 5 P.M., and at 6-30 P.M. the temperature had fallen to 100° (pulse 80, respiration 18). Next morning, at 7 A.M., the temperature was 101°, at 5 P.M. it was 100°, and at 6-30 P.M. it had risen to 103°. Creasote was again applied, and at 8-30 P.M. the temperature had fallen to 99·6°. Next morning, at 7 A.M., it was 100°. Since then the temperature has never been up to 103°, and creasote has not been applied again.

Case II.—Rifleman Parliman Thapa, 42nd Gurkha Rifles, age 34, was admitted into hospital on 24th October with lobar pneumonia of the right lung. His temperature at 4-25 P.M. of the day of admission was 103-4 (pulse 118, respiration 38). Creasote was applied in the usual manner, and at 6-30 P.M. the temperature had fallen to 100·6° (pulse 128, respiration 38). Next day, at 7-30 A.M., the temperature was 102°, at 10 A.M., 103°, at 3-15 P.M., 104·2°, and at 6-30 P.M. 103° (pulse 120, respiration 26). Creasote was again applied, bringing the temperature down to (101° pulse 128, respiration 28) at 7-30 A.M. next morning. Since then the temperature never reached 120°.

Case III.—Rifleman Narbir Thapa, 42nd Gurkha Rifles, age 25, was admitted into hospital on 28th October suffering from remittent fever. His temperature at 3-30 P.M. on the day of admission was 104·2°. Creasote was applied, and at 6-30 P.M. it had fallen to 97·4°. Next day the temperature was 98° in the morning, and 99° in the evening. On the third day the temperature gradually rose, reaching 104° at 3-45 P.M. on the fourth day. Creasote was again applied, and at 7 A.M. next morning the temperature had fallen to 99·8.

At 3-25 P.M. the temperature was 102°. Creasote was employed, and next morning the temperature was 99°.

After this creasote was not used till 14th November (the eighteenth day of his illness). On this occasion the temperature was 103° at 5 P.M., the time of application. Next morning at 7 A.M. it was 102°, and at 9-45 A.M. had fallen to 97°.

After this no more creasote was employed.

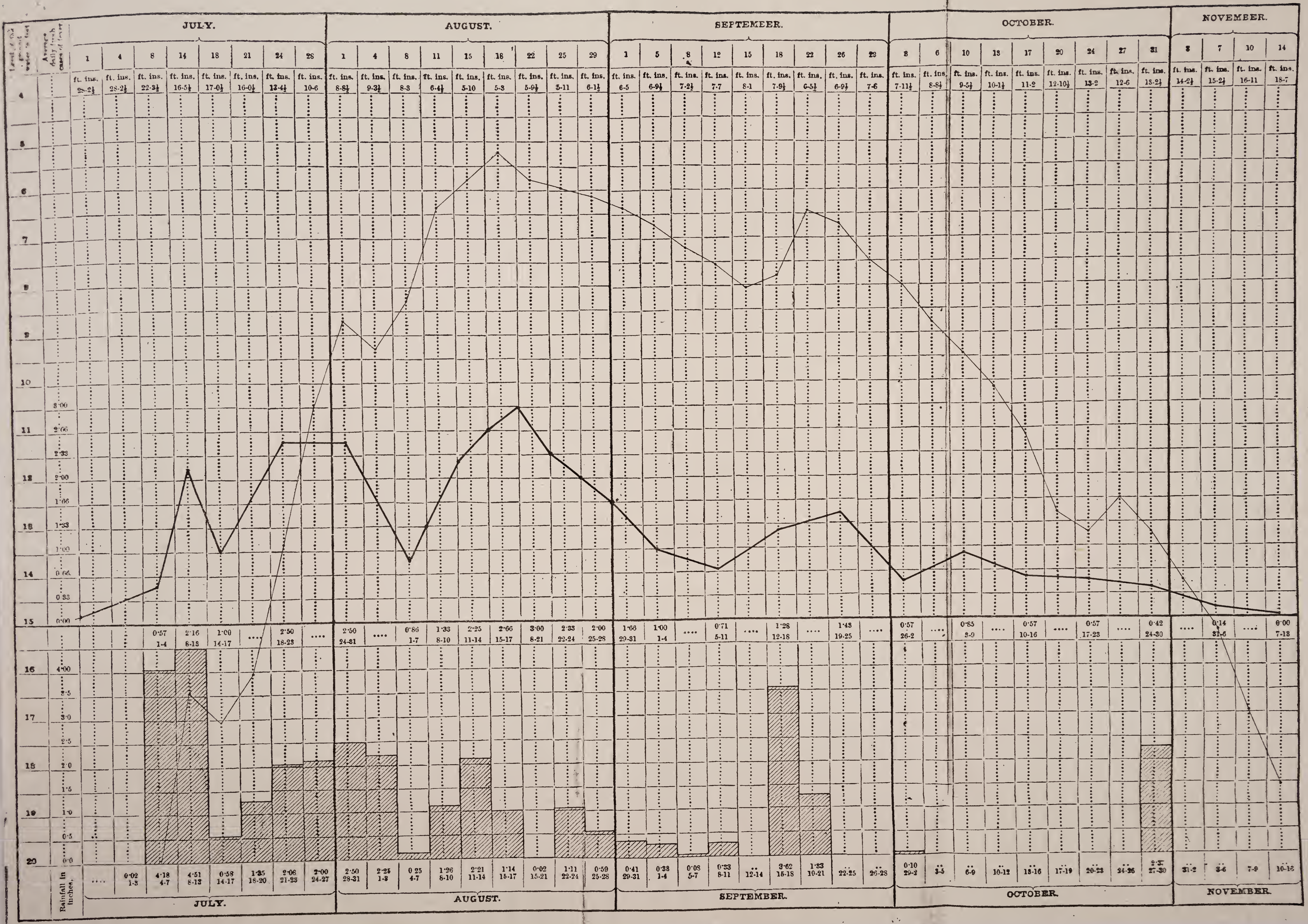
Case IV.—Rifleman Setia Lama, 42nd Gurkha Rifles, age 31, was admitted into hospital on 31st October with lobar pneumonia of the left lung. His temperature on admission at 7-30 A.M. was 103° (pulse 100, respiration 30). The application of creasote brought the temperature down to 102° at 3-15 P.M. (pulse 78, respiration 32). In the evening the temperature was 99° and remained so till next morning, rising to 102° in the evening. On the fifth day (4th November) the temperature was 103° at 4 P.M. At 8 P.M., after the application of creasote, it had fallen to 101°, remaining the same till next morning.

After this the temperature continued more or less irregular, never rising above 102° till the twelfth day when, at 7 A.M., it was 105°. Creasote was again tried: at 11 A.M. the temperature was 103,° at 3-30 P.M. 102,° and next morning, at 7-30 A.M. it was 97.° Since then the temperature has remained normal.

Case V.—Gun porter Sham Karen Nagerkoti, 42nd Gurkha Rifles, age 20, was admitted into hospital on 19th November with ague, his temperature being 104·6° (pulse 108, respiration 22).

Creasote was applied at 11 A.M., and at 11-30 A.M. the temperature was 99° (pulse 112, respiration 22). At 12 noon the temperature was 97° (pulse 98, respiration 20). After this there was no more rise of temperature.

In all the above cases there was diaphoresis; in some, profuse, in others, slight. There was no marked diuresis in any of them. The slightness of the diaphoresis and the rapidity with which the


Level of the ground water in feet
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AUGUST.
SEPTEMEER.
OCTOBER.
NOVEMBER.
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JULY.
AUGUST.
SEPTEMBER.
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